Logan Dam Site

Logan Dam site is located on Logan Creek, about 7 miles west to southwest of the town of Willows in Glenn County (Photo 38). The dam site extends from Section 20 to Section 29, R4W, T19N on the Logan Ridge 7.5-minute USGS topographic quadrangle map. Access is via private roads; the entire dam site is on the Elworthy cattle ranch. The proposed dam, in conjunction with the Sites Dam, Golden Gate Dam, Hunters Dam, and the northern Colusa saddle dams, would impound 3.0 million acre-feet of water in Colusa Reservoir. The dam would be a 270 foot-high earthfill embankment structure with a 7,200-foot crest length at an elevation of 540 feet. The embankment would completely cover the north-south trending main ridge and drape over into the lower areas east and west of the crestline.

Previous geologic work for the Logan Dam site was limited to a brief assessment performed by the Department for the Klamath-Trinity Development Project conveyance system in the 1960s. The current Northern District investigation consisted only of reconnaissance geologic mapping.

Photo 38. Aerial view of Logan water gap at Logan Dam site

Dam Site Geology

Foundation rocks are Cretaceous sedimentary rocks of the Cortina and Boxer Formations. These have been upturned to form a series of north- to northwest-trending homoclinal ridges that dip 55 to 75 degrees to the east. The Boxer Formation, primarily mudstone with some sandstone interbeds crops out along the western side of the ridge. The Venado sandstone member of the Cortina Formation, massive to bedded sandstone with minor mudstone interbeds, forms the ridge. Excellent exposures of the bedrock are found in Logan Creek where it cuts through the ridgeline.

The ridge top is generally covered with thin soil, and the side slopes are mantled with colluvium. Quaternary alluvial deposits cover bedrock locally and Quaternary terrace deposits occur along the stream channels at depths up to 20 feet. They consist of sand, silt, and gravel, mantled by a clayey soil.

Plate 10 presents DWR's geologic mapping. Plate 11 presents one geologic profile parallel to the dam axis, and one cross section perpendicular to the axis through the Logan Creek water gap.

Bedrock Units

The majority of the dam foundation is a ridge composed of interbedded Upper Cretaceous sandstone and mudstone of the Boxer and Cortina Formations. The foundation bedrock consists of about 55 percent mudstone and 45 percent sandstone.

These bedrock units were differentiated into mappable units (see Plates 10 and 11) as follows:

- KCVm - Mudstone (70 to 100 percent) with sandstone intervals (0 to 30 percent) up to 5 feet in thickness of the Venado member of the Cortina Formation,

- KCVs - Sandstone (70 to 100 percent) of the Venado member of the Cortina Formation with mudstone intervals (0 to 30 percent) up to 5 feet in thickness,

- KCVsm - Interbedded mudstones (30 to 70 percent) and sandstones (30 to 70 percent) of the Venado member of the Cortina Formation,

- KBm - Mudstone (70 to 100 percent) of the Boxer Formation with sandstone intervals (0 to 30 percent) up to 5 feet in thickness,

- KBsm – Interbedded mudstones (30 to 70 percent), and sandstones (30 to 70 percent) of the Boxer Formation.

Fresh sandstone is light to medium olive gray in color and yellowish brown where weathered. It is mostly a very fine to medium-grained well-sorted arkosic sandstone with a silty to clayey matrix. Bedding is massive to cross-bedded and outcrops in units ranging from less than a foot to tens of feet in thickness. It contains thin interbeds of siltstone and mudstone that range from laminar up to 5 feet in thickness. It is typically weathered at the surface. It is moderately to well indurated, moderately to slightly fractured, moderately hard to very hard and strong. Internal structure is well developed in the areas of cross bedding and vague where massive. Calcite healing along fractures is common, with some pyritization. The unit contains discontinuous beds of well-rounded coarse pebble conglomerates up to 5 feet in thickness and within 50 feet of the Boxer–Cortina contact. A thin fossiliferous bed occurs in the basal sandstone unit approximately 80 feet above the Boxer–Cortina contact. The fossil bed is 1- to 3-feet thick, and the fossils are composed predominantly of pelecypod shell fragments. The fossil bed matrix often grades to a fine pebble conglomerate, indicating a high-energy depositional environment (Photo 39).

Photo 39. Fossiliferous sandstone and conglomerate at Logan Dam site

Mudstone is the least resistant rock type in the area. Fresh mudstone is dark gray to black in color and tan where weathered. Bedding is thinly laminar with thin sandstone and siltstone interbeds. It is brittle and slakes when exposed to air and

moisture. It is moderately indurated to friable, moderately hard to weak and closely fractured.

Unconsolidated Deposits

Unconsolidated deposits at the dam foundation consist of Quaternary alluvium, stream terraces, colluvium, landslides, and older upper terrace deposits.

Quaternary Alluvium (Qal) is located in the active stream channel of Hunters Creek and tributaries and consists mainly of lean clay, silt, and poorly graded to well-graded sand, gravel, cobbles, and boulders. It occurs along the channel sides and as discontinuous deposits in the channel. Deposits are estimated to range up to 5 feet in thickness. Deposits of Qal were too small to show on the map.

Two Terrace deposits (Qt2 and Qt3) border the active stream channel both upstream and downstream of the dam axis. Qt2 is a broad flat surface 5 to 10 feet above the stream channel. Observed thickness ranges from 5 to 10 feet. Soil development is moderate. The upper part of this terrace is clayey silt with increasing clay content downward. Some gravel lenses are exposed along the sides of the incised stream. In places there is a clay bed at the base of the deposit. The color of the upper 3 feet is very dark grayish brown, grading lighter downward to brown. This terrace may be correlative with the Modesto Formation as mapped by Helley and Harwood (Calif., Sacramento Valley 1985). Qt3 is a higher topographic surface 10 to 20 feet above the stream channel and has some slope. In places the Qt2 surface is set into the Qt3 surface. Where exposed the Qt3 deposits are a brown (Munsell color-code 7.5 YR4/3), silty clay with some rounded gravel. The Qt3 surface merges with the colluvium along the ridge front.

Colluvium occurs at the base of the steeper slopes and consists of clayey silt and sand with angular rock fragments up to 10 feet in thickness.

Five small landslides have been mapped at or near the proposed dam axis. Three of them occur on the north-facing slope of the right abutment, and the other two occur on the moderately steep west-facing slope of the left abutment in the Boxer Formation. All five landslides are small earth flows or debris slides with thicknesses of 2 to 5 feet and should not affect the proposed dam foundation. The Red Bluff Formation occurs at the northern edge of the map outside of the dam footprint (Photos 40 and 41). The formation consists of medium to coarse gravels with abundant sand, silt and clay.

Structure

The primary structural feature at the Logan Dam site is the northerly striking, east-dipping homoclinal bedding of the Great Valley sequence. Local attitudes vary in strike from N3°E to N14°W, and bedding dips in an eastward direction, mostly ranging from 60 to 70 degrees at the south end of the dam site to 65 to 75 degrees at the north end.

Photo 40. Tertiary Red Bluff Formation overlying Cretaceous Boxer Formation

Photo 41. Contact between the Red Bluff and Boxer Formations (close-up)

Lineaments

Several lineaments have been identified in the bedrock at or near the dam site.

The northernmost lineament, L-1, crosses the dam alignment through a prominent windage approximately 3,600 feet north of Logan Creek and trends southwest to northeast (Photo 42). It is the most easily discernible lineament, with a definite shift in the rock units along the ridgeline. If this lineament is a fault, the sense of movement would be right lateral, with an apparent offset of 100 to 150 feet; and the fault plane would be near vertical. The lineament feature cannot be followed very far on either side of the ridgeline because of the sparsity of mappable sandstone units.

The middle lineament, L-2, crosses the dam alignment through a saddle about 2,400 feet north of Logan Creek and also trends southwest to northeast. If this lineament is a fault, the sense of movement would be right lateral, with an apparent offset of about 50 feet. Eastward, the lineament bifurcates with a splay trending east. Like L-1, the lineament feature cannot be followed very far on either side of the ridgeline because of the sparsity of mappable sandstone units.

About 2,000 feet north of Logan Creek and 400 feet south of L-2, a short lineament, L-3, crosses the dam alignment and also trends southwest to northeast. If this lineament is a fault, the sense of movement would be right lateral, with an apparent offset of less than 5 feet.

Photo 42. Lineament L-1 passing through the wind gap just above the center of the photo, with a noticeable shift in the ridge-forming sandstone.

Joints

No joints were mapped in the area of the dam site, except in a very small quarry site on the northwest side of the right abutment. Jointing is expressed at N80°W with a dip of 70 degrees east, and N45°W with a dip of 67 degrees east.

Foundation Conditions and Exploration

Logan Dam site was mapped by DWR's Northern District in November and December 1999. Mapping was easiest along the central sandstone ridges with generally good exposure of outcrops. At least two suspected faults traverse through the foundation. The rock at Logan Dam site should provide a good foundation for the proposed dam with minor to moderate stripping. Bedrock consists of sandstone, interbedded sandstone and mudstone, and mudstone. Because of the interbedded nature, the percentage of sandstone and mudstone vary widely. Overall, sandstone is estimated to form approximately 45 percent (ranging from 30 percent to 60 percent) of the total dam footprint, and mudstone is estimated to be about 55 percent (ranging from 40 percent to 70 percent) of the total dam footprint. The possibility and recency of faulting on the mapped lineaments has

not been determined. Foundation conditions are summarized in Table 21, and the surficial geology is summarized in Figure 8.

Left Abutment

This abutment has a slope angle averaging 45 degrees on the western face of the main ridge and a gentler slope (25 degrees) on the eastern face. A secondary lower ridge, composed primarily of sandstone, extends parallel to the main ridge from Logan Creek channel approximately 2,500 feet north where it becomes more subdued as the sandstone bed pinches out (Photo 43). In addition, the western portion of the abutment extends approximately 600 feet out into the very gentle slopes of the Boxer Formation.

Stripping requirements may vary from a few feet in the more competent ridge-forming sandstones to 15 feet in the mudstones of the Boxer Formation. Stripping estimates are based only on visual surface observation because no subsurface exploration has been completed at this time.

Vegetation on the left abutment consists exclusively of scattered grasses.

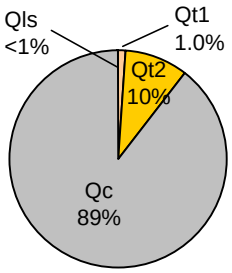
TABLE 21 – Colusa Reservoir Project, Logan Dam Site Foundation Conditions (total area of Dam Site Footprint = 8,684,800 feet^2)

FEATURE	SURFICIAL/BEDROCK GEOLOGY (by area in feet^2)*	CLEARING ESTIMATES	STRIPPING ESTIMATES	WATER LEVELS	GROUTING ESTIMATES	STRUCTURAL REMARKS
Left Abutment 74.9% of total area of dam footprint. More detailed mapping of dam footprint is needed.	Surficial Qls = 2,800 feet^2 (<1%) Qt_1 = 67,200 feet^2 (1%) Qt_2 = 620,100 feet^2 (10%) Qc = 5,815,300 feet^2 (89%) Total Area = 6,505,400 feet^2 Bedrock KBm = 2,683,300 feet^2 (41%) KCVs = 981,300 feet^2 (15%) KCVsm = 2,789,600 feet^2 (43%) KCVm = 51,200 feet^2 (1%) Total Area = 6,505,400 feet^2 Therefore: Ss = from 2,247,100 feet^2 (35%) to 4,296,900 feet^2 (66%) Ms = from 2,208,500 feet^2 (34%) to 4,258,300 feet^2 (65%)	Light: Scattered grasses interspersed between open sandstone outcrops.	Not Drilled	Not Drilled	Not Drilled	Two major lineaments cross the dam site approximately 2,400 feet north and 3,600 feet north of Logan Creek. These features have not been drilled.
Channel Section 13.2% of total area of dam footprint. More detailed mapping of dam footprint is needed.	Surficial Qls = 1,800 feet^2 (<1%) Qt_1= 146,300 feet^2 (100%) Total Area = 1,148,100 feet^2 Bedrock KBm = 914,500 feet^2 (80%) KCVs = 75,200 feet^2 (7%) KCVsm = 141,900 feet^2 (12%) KCVm = 16,500 feet^2 (1%) Total Area = 1,148,100 feet^2 Therefore: Ss = from 121,900 feet^2 (11%) to 473,800 feet^2 (41%) Ms = from 674,300 feet^2 (59%) to 1,026,200 feet^2 (89%)	Light: Light riparian bordering stream = grasses, trees, grasses on terrace deposits	Not Drilled	Not Drilled	Not Drilled	Not enough site-specific data has been gathered to evaluate.
Right Abutment 11.9% of total area of dam footprint. More detailed mapping of dam footprint is needed.	Surficial Qls = 5,200 feet^2 (1%) Qc = 1,026,200 feet^2 (99%) Total Area = 1,031,400 feet^2 Bedrock KBm = 592,000 feet^2 (57%) KCVs = 173,400 feet^2 (17%) KCVsm = 253,200 feet^2 (25%) KCVm = 12,800 feet^2 (1%) Total Area = 1,031,400 feet^2 Therefore: Ss = from 229,300 feet^2 (22%) to 556,000 feet^2 (54%) Ms = from 475,400 feet^2 (46%) to 802,100 feet^2 (78%)	Light: Scattered grasses interspersed between open sandstone outcrops	Not Drilled	Not Drilled	Not Drilled	Not enough site-specific data has been gathered to evaluate.

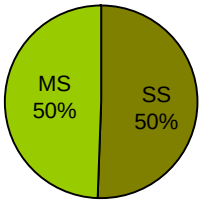
Ss = Sandstone Ms = Mudstone Cgl = Conglomerate Qal = Quaternary Alluvium Qc = Quaternary Colluvium Qt_1 = Quaternary Terrace (lower) Qt_2 = Quaternary Terrace (upper) Fx = fracturing
*** Total Foundation Area of Damsite Footprint = 8,684,800 feet^2, therefore total Ss = from 2,598,200 feet^2 (30%) to 5,326,700 feet^2 (61%); total Ms = from 3,358,200 feet^2 (39%) to 6,086,600 feet^2 (70%)**

FIGURE 8: Colusa Reservoir Project, Logan Dam Site Surficial and Bedrock Lithology By Percentage

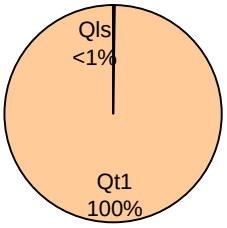
Areal Surficial Lithology of the Left Abutment



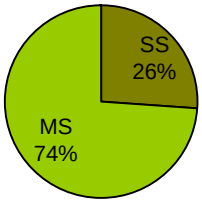
Areal Bedrock Lithology of the Left Abutment--Average Proportion of Sandstone and Mudstone



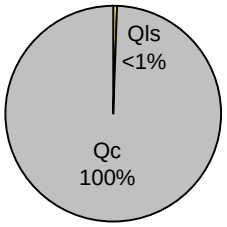
Areal Surficial Lithology of the Channel Section



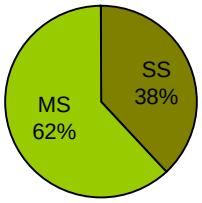
Areal Bedrock Lithology of the Channel Section--Average Proportion of Sandstone and Mudstone



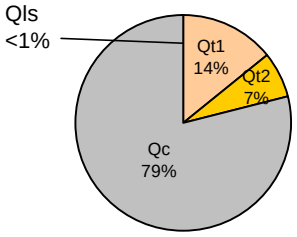
Areal Surficial Lithology of the Right Abutment



Areal Bedrock Lithology of the Right Abutment--Average Proportion of Sandstone and Mudstone



Areal Surficial Lithology of the Damsite Footprint



Areal Bedrock Lithology of the Damsite Footprint--Average Proportion of Sandstone and Mudstone

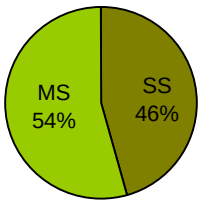


Photo 43. Northern view of left abutment and channel of Logan Dam site

Channel

The Logan Creek stream channel and its associated terrace deposits average 300 feet in width at the dam axis. The stream splits very near the dam axis, and terrace deposits occupy the areas between the two stream branches. The width of the intervening terrace deposit increases to 1,600 feet at the western edge of the dam footprint.

Bedrock is exposed in the base of the stream channel, with very minor deposits of recent Quaternary alluvium occupying lower areas in the channel. Depth of the Quaternary alluvium is estimated to be less than 5 feet. Terrace deposits alongside the stream channel may be as thick as 25 feet, based on visual inspection.

Stripping requirements include removing all of the exposed terrace deposits down to bedrock. Some bedrock underneath the terrace deposits may need to be removed.

Channel vegetation consists of scattered grasses and trees.

Right Abutment

This abutment has a slope angle averaging 50 degrees on the western face of the ridge and a slightly gentler slope of 35 degrees on the eastern face (Photo 44). In addition, the western portion of the abutment extends about 600 feet out into the very gentle slopes of the Boxer Formation. Stripping requirements may vary from a few feet in the more competent ridge-forming sandstones to 15 feet in the mudstones. Stripping estimates are based only on visual surface observation since no subsurface exploration has been completed at this time. Vegetation on the right abutment consists exclusively of scattered grasses.

Photo 44. Southern view of right abutment of Logan Dam site

The rock at Logan Dam site should provide an adequate foundation with minor to moderate stripping.

Not enough site-specific data have been gathered to analyze the requirements for grouting along the dam alignment. Core holes with water tests will be needed to evaluate the subsurface conditions at this site.

Faults uncovered in the foundation may require some cleaning and excavation of weakened and sheared rock before the embankment is placed. These faults/shears, beds, and joints are potential seepage paths through the abutments and will undoubtedly require grouting. Therefore, for estimating purposes, blanket grouting should be considered to seal near-surface fractures and joints.

Not enough detailed exploration has been performed to assess the clearing and stripping requirements over the entire 7,200-foot length of the dam.

Conclusions and Recommendations

Seismic Lines:

- Run one seismic line east-west through the Logan Creek water gap to evaluate the depth to bedrock.

- Run two north-south seismic lines across Logan Creek both upstream and downstream of the water gap to evaluate how thick the terrace deposits are on the abutments.

- Run at least one northwest-southeast trending seismic line across the lineament on the left abutment to investigate possible fault evidence in the recent overburden.

Drill holes:

- Drill two diamond core drill holes along the Logan Creek water gap to determine depth to bedrock, rock type, and permeability.

- Drill one diamond core drill hole in the right abutment to determine rock type and permeability.